ORIGINAL

Experimental Rocket Propulsion Society

COMMENTS

on the Federal Aviation Administration's

Notice of Proposed Rule Making:

Docket No. FAA-1999-6265; Notice No. 99-17

FAA-99-6265-4

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Report Contents:

1.0 Executive summary

The Federal Aviation Administration (FAA) has published a Notice of Proposed Rule Making (NPRM) on Financial Responsibility Requirements for Licensed Reentry Activities, including the reentry of Reusable Launch Vehicles (RLVs). The Experimental Rocket Propulsion Society (ERPS), a California-based 501(c)3 organization, is developing RLV and Single Stage To Orbit (SSTO) technology, with an interest in licensing its technology to commercial enterprises. ERPS' vehicles would be subject to FAA's proposed rule. As an interested party, ERPS is submitting comments on FAA's proposal. ERPS has commented on several issues that were raised in the NPRM; a summary of the points that ERPS believes to be the most important follows.

Definitions of mission phases. The proposed rule defines RLVs as having two mission phases: launch phase and reentry phase. The proposed definitions of the launch phase have launch ending when payload is deployed and separated. ERPS points out that orbital RLV missions will not always include the deployment of payload into orbit, making this definition of launch inapplicable to some missions. ERPS recommends that orbital RLVs be defined as having three mission phases: launch phase, on orbit phase, and reentry phase. ERPS further recommends that launch phase be defined as ending when the RLV's main engine(s) stop(s) and the desired trajectory or orbit is achieved. On orbit phase, for orbital RLVs, would commence at this point and last until reentry begins. Reentry phase would begin, for vehicles in low Earth orbit, at preparation for retrofire; for other vehicles, at preparation for atmospheric interface. Reentry phase would end when the vehicle's engines stop and the vehicle is properly parked.

Launch risk vs. reentry risk. FAA requests public comment as to whether, and in what circumstances, it might be appropriate to allocate reentry risks differently than launch risks. ERPS concurs with the Agency's contention that overall flight risk should be held to the current standard of

$E_C \leq 30 \times 1\ 0^{-6}$. ERPS also agrees with the Agency's opinion that launch and reentry risks for a given RLV are quite different. At launch, the vehicle is very heavy and has great explosive potential, but is probably at some remove from large population centers. At reentry, the same vehicle will have used most of its propellant, so it will be light and have little explosive potential. On the other hand, it will be moving at high velocity and have a great deal of kinetic energy. If something does go wrong, the vehicle is likely to be destroyed by atmospheric heating before it can cause much (if any) damage on the ground. Taking the above into consideration, ERPS believes FAA would be justified in allocating launch and reentry differently. ERPS has no recommendation one way or the other.

Passengers of RLVs. FAA is interested in the public's views on how passengers of RLVs should be regulated. Should they be treated as other space launch customers, or is another paradigm more appropriate? ERPS believes that to encourage the development of space tourism and promote equity, RLV passengers should be regulated the same as any other space launch customer. Passengers would be required, as a condition of buying a ticket to space, to waive their claims at the gate, and hold the launch vehicle operator, the travel agent, the launch site operator, the Government, and all other associated parties harmless from liability arising out the flight. In return, passengers would be able to buy a ticket to space and be held harmless for any liabilities they might incur.

The above issues, as well as others, are discussed in greater detail in the body of this report.

2.0 Introduction to these comments

The Experimental Rocket Propulsion Society (ERPS) was formed in 1993 as a nonprofit, liquid fueled rocket engineering design and test team based in the San Francisco Bay area. From its inception, ERPS has focused on developing low cost, high performance rocket vehicle technology. The goal of this development program is to build reusable vehicles and demonstrate dramatically lower costs of access to space.

It is our belief that vast potential for economic growth for the 21st century lies in the development of space resources. Developing space resources will require that the cost of getting from Earth's surface to low Earth orbit (LEO) be reduced by orders of magnitude.

ERPS has been developing low cost, high performance, safe, reliable rocket engine technology. We have developed a new catalyst for high test peroxide (HTP). This catalyst works with 100% HTP concentrations and does not deteriorate over time. We have also been developing small scale experimental aircraft-type platforms to test, implement, and demonstrate the advantages of this approach. After many years of being the lone voice in the wilderness touting the advantages of high density propellants (HTP and kerosene), we are now seeing established aerospace companies pay significant attention to the potential advantages of these propellants.

ERPS' current development program includes building and test flying vehicles in an incremental "build a little, test a little" approach, because this provides us the best opportunity to demonstrate reliability and reusability without incurring enormous development costs. The technology that ERPS is developing is being made available for nonexclusive licensing, and at present three separate companies have been spun off to market products based on ERPS research.

ERPS' development programs include vehicles that would be regulated by FAA's proposed rule. ERPS finds most of the proposed rule to be sound and sensible. However, there is still ambiguity in the proposed regulation of RLVs. The difficulty appears to stem from an assumption by FAA that the only mission RLVs will fly is payload deployment. While it is true that ELVs, by their nature, can only deploy payloads, RLVs are more flexible. As the U.S. Space Shuttle routinely demonstrates, payload deployment is not the only mission an RLV can fly.

ERPS commends FAA for their efforts in this area, and looks forward to a mutually beneficial relationship with FAA as we work together to open this new frontier.

3.0 Comments on issues raised by the NPRM

ERPS wishes to comment on several issues that were raised in different sections of the NPRM. Although many of the points made in this section are also covered in the page by page comments in Section 4.0, each of the following issues is important enough and broad enough to warrant separate comment.

3.1 Definition of outer space

FAA has not defined an altitude where outer space begins. ERPS recommends that FAA adopt the Federation Aéronautique Internationale's defined altitude of 100 km. An acceptable, although less preferable, definition to adopt would be the USAF's defined altitude of 50 miles.

3.2 Definitions of mission phases

Orbital RLV mission fall naturally into three distinct phases: launch, on orbit operation, and reentry. Launch begins with pre-flight ground operations that are hazardous and unique to space transportation. FAA proposes that launch end with payload deployment; ERPS disagrees, and proposes as an alternative engine cutoff after orbital insertion. On orbit operations are those activities between launch and reentry; some vehicles, and some missions, may not conduct any on orbit operations. FAA proposes that reentry begins immediately after launch ends; ERPS disagrees, and proposes as an alternative preparation for retrofit-e. Reentry ends after landing, with the completion of post-flight ground operations that are hazardous and unique to space transportation.

ERPS recommends that FAA change its definition of when launch ends. FAA's proposed definition of payload deployment as the end point for launch does not adequately

address vehicles or missions that do not deploy payloads.

ERPS further recommends that FAA change its definition of when reentry begins. FAA proposes to define the reentry phase as beginning when the launch phase ends. Launch phase is defined as ending when the payload is deployed into orbit. This would preclude on orbit operations. It only makes sense for reentry to immediately follow launch if the purpose of every mission is to deploy a payload into orbit. If the RLV's mission is something other than deploying a payload into orbit, such as quickly delivering payload point to point on Earth, then by FAA's own proposed definitions of launch and reentry, the launch phase would never end, nor the reentry ever begin, for that mission. Since the RLV would not "deploy" its payload until it returned to the Earth's surface, technically it would return and land without ever entering a reentry phase. RLVs need to have at least three defined mission phases instead of only two: launch phase, optional on orbit phase, and reentry phase.

3.4 Launch risk vs. reentry risk

FAA requests public comment as to whether, and in what circumstances, it might be appropriate to allocate reentry risks differently than launch risks. ERPS concurs with the Agency's contention that overall flight risk should be held to the current standard of $E_C \leq 30 \times 1\ 0^{-6}$. ERPS also agrees with the Agency's opinion that launch and reentry risks for a given RLV are quite different. At launch, the vehicle is very heavy and has great explosive potential, but is probably at some remove from large population centers. At reentry, the same vehicle will have used most of its propellant, so it will be light and have little explosive potential. On the other hand, it will be moving at high velocity and have a great deal of kinetic energy. If something does go wrong, the vehicle is likely to be destroyed by atmospheric heating before it can cause much (if any) damage on the ground. Taking the above into consideration, ERPS believes FAA would be justified in allocating launch and reentry differently. ERPS has no recommendation one way or the other.

3.5 Passengers of RLVs

FAA asks for public comment on *"the nature of the regulatory program that would be required to address passenger safety issues in space."* All ERPS reviewers had the same initial opinion on this topic: space travel passengers should be treated the same as air traveler passengers are. The Warsaw Convention, the Federal Aviation Regulations, and other pertinent laws and regulation would all apply. On reading FAA's questions, however, each reviewer independently came to the conclusion that FAA's example, regulating passengers the same as any other space launch customers, was more appropriate to a fledging industry. ERPS has a further recommendation for regulation of space vehicle passengers: we believe prudence dictates that FAA require passengers to carry insurance to cover possible personal catastrophic loss. ERPS believes the FAA's "value of human life" of $3,000,000 is an appropriate personal minimum probable loss.

4.0 Detailed comments on the NPRM, page by page

64 FR 54452, paragraph 4*: 'FAA'S recently issued licensing regulations define the term "launch" to include ``pre-flight ground operations beginning with the arrival of a launch vehicle or payload at a U.S. launch site." 14 CFR 401.5. See 64 FR 19586-19624. The RLV Licensing Regulations propose to continue use of this definition with respect to RL V launches. 64 FR at 19655.'*

ERPS recommends against continued use of this definition for RLVs. Given this definition, an RLV that returned to its launch site would begin its next launch as soon as it touched down after returning from its current flight. Since reentry does not logically end until after the vehicle has come to rest and hazardous post-flight operations are complete, the same vehicle would then simultaneously be in the reentry phase of its current flight and the launch phase of its next flight. Clearly, this is absurd.

ERPS recommends that FAA modify its definition of launch for RLVs to more accurately reflect the intent of the CSA, as in 49 USC 70102(3): *"activities involved in the preparation of a launch vehicle or payloadfor launch, when those activities take place at a launch site in the United States. "* **Thus,** even after an RLV has returned to its launch site, its launch should not be deemed to have begun until preparation of the vehicle for its next flight has begun. This necessitates tying the definitions of reentry and launch to ground operations, rather than specific marker events, but this is appropriate to reusable vehicles as a class.

As an example, we can look to the U. S. Space Shuttle. A Shuttle's reentry is logically over after it has landed and all hazardous post-flight operations (purging hypergolic propellants, for example) are complete. It undergoes refurbishment, is transported to KSC if it landed elsewhere, and begins processing for its next mission. At whatever point in pre-flight processing hazardous operations occur, its next launch logically begins.

64 FR 54452, paragraph 7: *'FAA proposes instead to limit the definition of "launch" that appears in 14 CFR 401.5 to EL V launches and to use accomplishment of the launch phase of the mission, that is, the point ofpayload deployment (or attempted payload deployment), to define the end of licensed launch activities when the launch vehicle is an RLV. If adopted in final rules, this definition offers the added benefit ofproviding a bright line reference point for distinguishing the end of licensed launch flight from other mission phases for most RL V activities that will occur in the foreseeable future.'*

ERPS notes that using payload deployment to mark the end point for launch is appropriate only for RLVs whole sole mission is payload deployment. ERPS foresees other missions for RLVs: payload retrieval, passenger transport, micro-gravity experimentation, and point-to-point cargo transport are all likely missions for RLVs.

The major problem ERPS sees with FAA's proposed definition of payload deployment as the end point for launch is the introduction of regulatory surrealism for RLVs that do not deploy payloads: for regulatory purposes, the launches of these vehicles would never end. This could lead to, for example, a vehicle still being launched, regulatorily, while it is sitting on the ground the next day being washed. Since it is clearly in the best interest of the industry that regulation correspond as closely as possible with reality, ERPS recommends that FAA modify the proposed definition of the end point for launch.

ERPS recommends that the end point for launch be engine cutoff after vehicle insertion into the desired orbit or trajectory. As an alternative, FAA's proposed definition of payload deployment could be used for those missions which deploy payloads, with ERPS' proposed definition used where no payload is deployed. ERPS' proposed definition could be interpreted to include a circularizing burn as part of launch, even though it occurs many minutes after main engine cutoff (MECO); this would be appropriate, as the vehicle has not attained its desired orbit before the circularizing burn.

64 FR 54452, paragraph 9: *'The proposed RL V Licensing Regulations define "reentry" to include "activities conducted in Earth orbit or outer space to determine reentry readiness and [that] are therefore unique to reentry and critical to ensuring public health and safety and the safety ofproperty during reentry." 64 FR at 19656.'*

ERPS concurs with this proposed definition.

64 FR 54452, paragraph 9: *'The accompanying Supplementary Information further explains that licensed reentry activity would commence at the point following payload deployment when vehicle hardware and software begin to be readiedfor reentry. Once a payload has been deployed, RL V operations, whether designed into the vehicle or controlledfrom Earth, would be directed at readying the vehicle for reentry and verifying reentry readiness of structures, propulsion systems, and vehicle orientation, attitude and safety systems, including software. See 64 FR at 19632-33.'*

ERPS recommends striking the phrase *"followingpayload deployment"* and replacing the phrase *"once a payload has been deployed'* with "once the mission has been completed."

64 FR 54452, paragraph 9*: for those RLVs intended to remain on orbit for a relatively brief duration, such as days or possibly weeks, the RL V Licensing Regulations provide that the licensed reentry phase of an RL V mission would therefore commence* ***immediately*** (ERPS emphasis) *following payload deployment.'*

ERPS finds no rationale in Congressional language or FAA documents for defining reentry to begin **immediately** after payload deployment. The House Committee on Science noted that ``*for purposes of the license requirement, reentry begins when the vehicle is prepared specifically for reentry. By way of definition, the Committee intends the term to apply to that phase of the overall space mission*

during which the reentry is intentionally initiated. Although this may vary slightly from system to system, as a general matter the Committee expects reentry to begin when the vehicle's attitude is orientedfor propulsion firing to place the vehicle on its reentry trajectory. " H. Rep. 105-347, 105th Cong., 1 st Sess., at 2 1. ERPS believes that deploying a payload does not constitute an intention to reenter, and that FAA's definition of payload deployment as the beginning point for reentry does not satisfy the Committee's definition.

ERPS believes that reentry begins, for vehicles in Earth orbit (or otherwise in outer space), at preparation for retrofire; for suborbital vehicles, at preparation for atmospheric interface. We believe our view is supported by the House Committee on Science.

64 FR 54453, paragraph 5*: 'for safety reasons comparable to those underlying the FAA's determination that "launch" includes preparatory activities preceding vehicle flight, the FAA has proposed in the RL V Licensing Regulations to define "reentry" to include those "activities conducted in Earth orbit or outer space to determine reentry readiness and are therefore unique to reentry and critical to ensuring public health and safety and the safety ofproperty during reentry. " 64 FR at 19656.'*

ERPS concurs with this proposal.

64 FR 54453, paragraph 5: *'The event ofpayload deployment appropriately marks the end of licensed launch flight and would be followed immediately thereafter by reentry activities comprehended by the FAA's licensing authority. '*

ERPS believes that payload deployment will not always be part of the mission, and so is not an appropriate marker event for the end of licensed launch flight. ERPS further believes that reentry

will not always be intended to occur immediately after payload deployment. ERPS is troubled by the possibility that FAA will, by defining reentry inappropriately, require reentry to begin immediately after payload deployment, thus forbidding on orbit operations. ERPS believes reentry should be defined so as to permit on orbit operations after launch is complete.

64 FR 54453, paragraph 6: '*It* [a seamless risk management approach] *would also apply to those vehicles intended to spend minimal time on orbit and subsequently reenter purposefully upon activation or initiation of a reentry system once reentry readiness has been verified.*'

ERPS concurs with this statement, noting that it contains no language defining reentry as beginning immediately after payload deployment.

64 FR 54454, paragraph 4: *'For example, if under the terms of an FAA license, reentry of a reentry vehicle may only be attempted under defined circumstances (such as attainment by the vehicle of certain prescribed orbital characteristics, including attitude, system status and inclination), and the reentry licensee is unable to verify that it has satisfied the conditions necessary to conduct a licensed reentry, the licensee would be required to abort the reentry attempt because it cannot be accomplished under the safety limitations defined in the license.* '

ERPS notes that a random reentry would probably pose less risk to the public than a non-nominal reentry, because most of the Earth's surface area is deep ocean, and most of Earth's land area is sparsely populated. ERPS also notes that a random reentry would almost certainly destroy the vehicle: if it didn't burn up, it would probably crash in rough terrain. Does FAA have any plans to specify under what conditions the licensee is forced to accept a random reentry and the probable loss of the vehicle? How would such plans be affected by the presence of a crew on the vehicle? How

would such plans be affected by the presence of passengers? ERPS believes that if crew and/or passengers were aboard a stricken RLV, MPL considerations alone would make the humanitarian decision - trying to save the ship - the obvious choice.

64 FR 54454, paragraph 5: *'although the FAA does not propose to regulate on orbit activity other than to assure reentry safety, the FAA proposes to license pre-descent activities, on orbit or otherwise in outer space, commencing at the point ofpayload deployment from an RLV, and to require insurance for vehicle operations while on orbit in the event ofpremature, errant, or otherwise non-nominal reentry. '*

ERPS believes that FAA is saying here, "We won't regulate on orbit operations, except when we will." ERPS disagrees with FAA that pre-descent activities begin at payload deployment; our reasoning is given at length elsewhere in these comments. ERPS believes it is reasonable to require insurance for on orbit operations; it's getting crowded up there. However, ERPS does not believe defining all on orbit activities as pre-descent activities subject to license is a legitimate rationale for requiring insurance.

ERPS understands and appreciates FAA's desire to ensure reentry safety. We dispute **FAA's** proposed rationale. ERPS notes that an errant or otherwise non-nominal reentry is nevertheless a purposeful, intentional event, meets FAA's proposed definition of licensed reentry activity, and would be regulated as such. ERPS considers premature reentry to be an unintentional event (assuming it is not an abort, contingency, or other unplanned but deliberate action).

As ERPS understands it, the problem is that in FAA's view, a premature reentry cannot be considered a licensed activity unless FAA licenses on orbit activity. This would result in claims from a premature reentry being ineligible for indemnification. This would be an undesirable outcome.

However, FAA's proposed solution to the problem, licensing on orbit activity as part of reentry, is also an undesirable outcome, in ERPS' opinion.

64 FR 54455, paragraph 3: *'Nor would statutory financial responsibility coverage apply to anything that occurs as a result of a license having been issued.'*

64 FR 54455, paragraph 3: *'Likewise, mere intent to engage in licensed activity would also not satisfy the statutory requirement, in the FAA's view.'*

ERPS agrees with each of the above statements, taken alone. We believe, however, that issuance of a license and intent to reenter, together, satisfy the statutory requirement, and premature reentry would be eligible for indemnification as another type of non-nominal reentry.

ERPS believes that its proposal and FAA's proposal both accomplish FAA's desire to indemnify premature, errant, or otherwise non-nominal reentry. ERPS believes that its proposal better satisfies Congressional intent that FAA not regulate space activity unrelated to launch or reentry.

64 FR 54455, paragraph 7: *'RLVs that achieve neither Earth orbit nor outer space would be regulated in accordance with the FAA's licensing authority over launches of launch vehicles in a suborbital trajectory.'*

64 FR 54455, paragraph 8: *'Where a suborbital RLVenters outer space, its launch and reentry would be subject to separate and distinct MPL determinations based upon the unique risks posed during each flight phase . . .'*

64 FR 54455, paragraph 8: *'Suborbitally operated RLVs that do not achieve outer space would be subject to a single determination of financial responsibility only...'*

ERPS notes that neither the Congress nor FAA has defined "outer space," and believes the above statements would benefit from such a definition. ERPS proposes FAA adopt FAI's definition of 100

km above mean sea level (MSL). Alternatively, FAA could adopt the U.S. Air force's definition of 50 miles above MSL. As a third alternative, FAA could leave "outer space" undefined, and let the courts figure it out. ERPS does not recommend the latter alternative.

64 FR 54456, paragraphs 3-5: (not quoted)

ERPS endorses FAA's basic proposal, with enthusiasm.

64 FR 54457, paragraph 7: *'With the development of RL V technology comes the possibility of crewed or piloted launch vehicles whose operations would be subject to FAA licensing. For purposes of financial responsibility and risk allocation, the FAA regards the crew of a launch vehicle as employees of a private party launch or reentry participant (PPLP or PPRP, respectively) and therefore financial responsibility for their claims for damage, injury or loss would be addressed through reciprocal waiver of claims the same as claims of other PPLP or PPRP employees.'*

ERPS concurs with FAA, that RLV crew members are employees of the RLV operator.

64 FR 54557, paragraph 8: *'FAA is interested in the public's views on the subject and, for purposes of a future rulemaking, how passenger risk should be allocated.'*

ERPS reviewers were initially of the unanimous opinion that space vehicle passengers should be treated just like air travel passengers, Warsaw Convention, FARs, and all. When we read FAA's questions (below), though, we all decided FAA had a better idea, more appropriate to an embryonic industry.

64 FR 54557, paragraph 8: *'For example, shouldpassengers be regarded as any other customers who are expected to waive claims against other participants for injury, damage or loss as a result of launch or reentry?'*

Yes. Space travel will soon be part of the adventure tourism market, and "hold harmless" is common in that market. Space tourism will be good for America, as it will help establish America and Americans as world leaders. FAA should promote this development, and one way to promote it is to create a regulatory environment that minimizes litigation and other finger-pointing and name-calling. Treating passengers as launch and reentry service customers would mesh well with other space business, and would avoid the creation of regulatory ambiguity.

64 FR 54557, paragraph 8: *'Should the Government play a role in establishing limits on liability for injury to space vehicle passengers?'*

Yes; the limit should be zero, as above. Passengers shall waive their claims against other participants. However, this is not the only limit the Government should set. The Government should also set a minimum level of personal insurance for space vehicle passengers. Treating passengers as customers will reduce business risk for the commercial operators of space tourism, but it won't reduce the passengers' risk. Nothing in current regulations requires launch participants to carry insurance to cover their own losses, nor should such a requirement exist. For passengers, however, the bar should be raised: space vehicle passengers should be required to carry personal insurance sufficient to cover their personal minimum probable loss. ERPS recommends the FAA's "cost of human life" figure of $3,000,000, adjusted for inflation, as a personal MPL. This requirement could be met with a combination of life insurance, medical insurance, disability insurance, and personal savings. The cost of such insurance will likely be proportional to the cost of a space vehicle ticket: as RLVs achieve higher flight rates, their costs will go down, and as they achieve statistically significant

safety records, passengers' insurance costs will go down.

64 FR 54557, paragraph 8: *'Should indemnification be extended to cover risks of liability to passengers? '*

Yes; this is only fair. If passengers must bear the same risks as other participants, it is only equitable that they be indemnified against liability, as are other participants.

64 FR 54459, paragraph 8: *'Persons other than prospective reentry licensees may request an MPL determination for their activity and the FAA would like to accommodate requests for advisory MPL determinations, as reflected in proposed Sec. 450.7(e).'*

ERPS applauds FAA's proposed accommodation as an excellent example of regulatory flexibility.

5.0 Closing statements

ERPS acclaims FAA for producing a clear, well written, well reasoned proposal. There is much in the NPRM that we like and approve of; FAA has nearly completed the paradigm shift required to regulate RLVs as a vehicle class separate and distinct from ELVs. With minor revision, ERPS believes the proposed rules will well serve the emerging RLV industry and help realize the vast potential that will be available with the substantial lowering of launch costs.

ERPS is pleased to have had this opportunity to comment on these issues, and to submit detailed comments on the NPRM. We hope that the information in this document has been useful, and that we have contributed in a positive way to a comprehensive and workable final rule. We additionally hope that FAA will be interested in calling on ERPS for further input on this and related issues.